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MAGNETOSPHERIC SPACE PLASMA INVESTIGATIONS

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MAGNETOSPHERIC SPACE PLASMA INVESTIGATIONS

SCIENTIFIC INVESTIGATIONS

O^+ Outflows

A paper [Ref. 1] describing the centrifugal acceleration effects on the polar wind appeared in the August 1994 issue of the Journal of Geophysical Research. It was shown that for an exactly polar field line, the outward ion acceleration is given by

$$a = 1.5(E_i/B_i)^2(1/r_i^3)r^2$$

We found that for a 50 mV/m ionospheric convection electric field, the steady-state O^+ bulk velocities increase from near 0 km/s at 4000 km altitude to about 10 km/s at 5 R_E geocentric, which is in reasonable agreement with previous observations of large O^+ outflow velocities. The centrifugal force further has a pronounced effect on the escaping O^+ flux, especially for cool exobase conditions; as referenced to the 4000-km altitude, the steady-state O^+ flux increases from 10^5 ions-cm^{-2}-s^{-1} at E_i=0 mV/m to 10^7 ions-cm^{-2}-s^{-1} at E_i=100 mV/m.

We also completed the survey study of properties of outflowing polar cap O^+, based on RPA analysis of DE-1 RIMS data, which included a comparison with parameters from the above centrifugally-accelerated polar wind. The paper [Ref. 2] was submitted to and accepted by Geophysical Research Letters and will appear this fall.

Generalized SemiKinetic Model

During this period four projects have been pursued vigorously. The first was an effort to develop a time-dependent semikinetic model for the 200 km to 1 R_E altitude range for H^+ and O^+ ions. The model includes self collisions and ion-neutral collisions and chemistry. Originally we hoped to have the model working in time to present results at the spring AGU meeting, but were not able to meet that schedule. Since May we have been able to get the model working. The second project involves modeling of light ion outflow in the polar cap transition region and comparison of the results with data. The modeling work was finished during this time as was the initial data comparison work. Results of this study were presented at the spring AGU meeting [Ref. 3] and the COSPAR meeting [Ref. 4]. The third project involves a model study of wave heating of O^+ ions in the topside transition region. For this work we are using a code which does local calculations that include ion-neutral and Coulomb self collisions as well as production and loss of O^+. A new graduate student, Doug Gristina is doing this work and has made very good progress in the last three months. The fourth project is a statistical study of hydrogen spin curve characteristics in the polar cap. A participant in the UAH Physics Department summer Research Experience for Undergraduates (REU) program, Bill Reaves from Auburn, has been working on this project during the summer. He has found a way to characterize the spin curves so that they can be grouped according to their skews and shapes. With this characterization we plan to look for correlations between spin curve type and location or geophysical conditions.

We have submitted a paper [Ref. 5] to JGR on the GSK modeling of the synergistic interaction of transverse heating of ionospheric ions and magnetospheric plasma-driven electric potentials including an examination of the evolution of the pressure cooker mechanism for energetic ion conics. In this work, we specified magnetospheric hot anisotropic ion and electron analytic bi-Maxwellian distributions at the top boundary of our simulation region, nominally 4 R_E geocentric. For example, if the hot ions are more peaked at 90° than the electrons, a downward electric field results. We then assumed a distribution of electric field wave power spectra along the magnetic field lines which produced ion perpendicular velocity diffusion, and allowed the ionospheric plasma to flow in from the bottom. With the perpendicularly-peaked hot ions producing a downward electric field, H^+ was energized to about 120 eV. We also saw a population of large downward fluxes of ~50 km/s H^+ which were trapped between the downward electric field above and the heating and upward mirror force region below. This situation thus represents a partially self-consistent dynamic model for the "pressure cooker" concept for energizing conics.

We have continued with our work on partially self-consistent Generalized SemiKinetic (GSK) model for ion conic production via the Current-Driven Ion Cyclotron Instability (CDICI) and will soon submit a full paper to JGR on this [Ref. 6].

Abstracts for poster presentations at the upcoming workshop in Guntersville have been submitted on GSK modeling of effects of auroral electron precipitation on ionospheric plasma outflow [Ref. 7] , on **E**×**B** effects on such outflow [Ref. 8], and on warm plasma thermalization and other effects during refilling with pre-existing warm plasmas [Ref. 9].

Field-Aligned Flows and Distributions

We also completed and submitted a statistical study of the latitudinal distributions of core plasmas along the L=4.6 field line using DE-1/RIMS data [Ref. 10] . We studied those orbits for which the spacecraft was approximately skimming this L-shell, and for which the low-energy ions were trapped distributions at the equator and counterstreaming off the equator. We analyzed approximately 40 such orbits, and characterized parameters such as the ratio of equatorial-trapped to 45° flux or equatorial anisotropy, the latitudinal half-width of the anisotropy, the transition latitude where ions exhibit significant anisotropy, the penetration ratio of field-aligned fluxes in the vicinity of the equator to outside the transition, and the latitudinal scale length of the trapped ion flux variations near the transition latitude. Various types of occurrence frequency relationships have been deduced. Perhaps the most interesting result is that we find an inverse relationship between the equatorial anisotropy and the penetration ratio. This is understood as the result of enhanced positive electrostatic potential associated with increased ion equatorial anisotropy producing a reduced equatorial penetration of the field-aligned ions.

Plasmasphere-Ionosphere Coupling

A short paper [Ref. 11] on dual spacecraft estimates of ion temperature profiles and heat flows in the plasmasphere-ionosphere system was prepared and submitted to Annales de Geophysique. In this study, we examined a limited set of DE1/DE2 conjunctions and used the temperatures obtained at two altitudes along specific field lines to integrate a simplified heat conduction dominated equation for the variation of temperature along the magnetic field lines. The resulting temperature profile is used to estimate the ion heat fluxes into the ionosphere as well as compare the profile with additional temperature points from "multiply-crossed" L-shell observations. The ion heat fluxes are observed to be in the range of 10^{-8} - 10^{-7} Joules/m^2/sec for the inner plasmasphere and up to 10^{-5} Joules/m^2/sec in the outer plasmasphere. Also, we find some cases where the additional data points on the "multiply-crossed" L-shell sets lie fairly close to the temperature profile obtained by using the highest and lowest DE1/DE2 temperature points as boundary conditions.

ANALYSIS TECHNIQUES AND SOFTWARE DEVELOPMENT

Empirical Model

The recently completed automated processing code has been used to process RIMS data from 1981 to 1984, and we have begun examining the resulting data base. An REU student, Sean Wolfe, has helped by plotting temperatures and densities for H^+ and O^+ so that we can begin to assess the quality of the data and the trends which are evident. One significant result is that on average the heavy ions (O^+) are basically in thermal equilibrium with the light ions (H^+ and He^+). In looking at the available data, we find that for low solar activity (F10.7 < 120) there are very few observations at low L-shells (<2). Those that do exist appear to show signs of detector degradation, i.e. temperatures are unrealistically high and densities are unrealistically low. Mean values for medium and high solar activity appear to be consistent with one another and with expectations from previous observations, although large standard deviations indicate wide variations. More detailed analysis is required to assess data quality to determine if there is a steady degradation in the data or if the nature of the end head-head analysis approach is simply very sensitive to small anomalies in the data. The former can be remedied fairly readily, while the latter will be more difficult to treat.

HARDWARE

Significant progress has been made toward prototype testing and assembling of MSFC's TECHS detector and supporting components in preparation for initial integration, which is scheduled for Sept. 19, 1994.

MEETINGS

Drs. Horwitz, Wilson, and Mr. Jinsoo Lee attended the Fall AGU meeting in Baltimore. Mr. Lee presented a poster on the effects of pre-existing hot plasmas on refilling [Ref. 12]. Dr. Horwitz was author or co-author of two papers [Ref. 12,13] and Dr. Wilson, four [Ref. 3,12-14]. Dr. Comfort was co-author on two papers [Ref. 15,32]

Drs. Comfort and Wilson attended the 30th COSPAR Scientific Assembly in Hamburg, Germany. Dr. Comfort was on the organizing committee for the symposium on Processes active at the Ionosphere-Magnetosphere Interface and was chairman for two sessions; he also presented an invited paper on plasmasphere thermal structure [Ref. 17]. Dr. Wilson was chairman for one session and referee for another; he presented an invited paper on the transition from collisional to collisionless ion outflow [Ref. 4].

PUBLICATIONS

In addition to those noted above, the following papers are at the indicated stage in the publication cycle:

Papers published:
The monograph from T. Chang's conference on Frontiers and Controversies in Space Plasma Physics finally appeared, with articles from our group on comparison of hydrodynamic and semikinetic results for density perturbation in the polar wind [Ref. 18], hemispheric decoupling in plasmasphere refilling due to equatorial heating [Ref. 19] and an invited paper on L=4-7 core plasma evolution as a starting point for understanding magnetosphere-ionosphere plasma couplings [Ref. 20]. Our description, for workers in rarefied gas dynamics, of some of our recent results of semi-kinetic transport treatment of magnetosphere-ionosphere coupling appeared in the AIAA monograph [Ref. 21]. The comparison of semikinetic and hydrodynamic models for plasma flow on closed magnetic field lines appeared in JGR [Ref. 22], as did the observational study of equatorial heating and hemispheric decoupling [Ref. 23] and the study of nighttime heating events in the topside ionosphere [Ref. 24].

Papers accepted and in press:
The paper on pitch angle distributions of thermal ions at high latitudes [Ref. 25], and the paper on $\mathbf{E}\times\mathbf{B}$ outflows of O+ [Ref. 16] have been accepted by JGR.

Papers submitted:
We prepared and submitted the IUGG 1991-4 Quadrennial report on ionospheric outflows and ionospheric plasma in the magnetosphere [Ref. 26]. A paper on substorm effects on O^+ outflow was submitted for the monograph on Substorms [Ref. 27]. A paper on topside ionospheric composition and temperatures was submitted to JGR [Ref. 28]. A paper on the azimuthal variation of the plasmapause was submitted to JGR [Ref. 29]. A paper on plasmasphere thermal structure was submitted to Advances in Space Research [Ref. 30], as was a paper on the transition from collisional to collisionless flow [Ref. 31].

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